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A BRACKET

The present invention relates to components joined together using structural joints and more particularly to brackets used for securing components together in such joints.

Brackets are commonly made from metal or metal alloys, such as steels and aluminium alloys, being formed in a shape that matches the profile of the joint of the components they are intended to secure. Fasteners such as rivets or bolts attach the bracket to the components it is joining together. The shape of the bracket allows it to support and stiffen the joint and provide a load path to transfer loads from one component to another.

In aircraft manufacture such brackets are regularly used for joining aircraft structural components and are known as 'cleats'. They are particularly used to join wing ribs to wingskins and to their associated stringers; equivalent rib, skin and stringer components in tail-fins, horizontal tail-planes and similar structures, and fuselage frames to fuselage skins and their associated stringers.

Most aircraft structural components are manufactured from aluminium alloy and it is standard practice to manufacture cleats for use with such components from aluminium alloy also. Occasionally, other metallic materials like titanium alloy or steel are used for aircraft structural components and any associated cleats would normally be made of a similar material to the surrounding structure, as the bracket will then have similar material properties and thus strength characteristics to the structure.

The brackets are designed to have the necessary strength characteristics to support, stiffen and act as a load path for the attached components and thus not fail at loads expected at the joint in question. For highly loaded structures this means the brackets have to be made of relatively thick material, as indeed are the components. If the joint is complex, (e.g. four separate components being joined together at varying angles to a given normal) then the shape of the bracket will also be complex. If either of both these requirements are necessary, normal manufacture is by forging followed by

machining to finish the bracket. The majority of brackets used for aircraft manufacture, especially jet airliners, are high loaded and complex in shape, thus each individual bracket can be a relatively expensive item, due to the complex forging tooling requirements, (different for each bracket design) and further process step of 'finishing', machining the bracket to the finished shape, (considering that there may well be hundreds of individual brackets of many different shapes in a single aircraft) these brackets can add significantly to the cost of manufacture of the aircraft. Indeed, large aircraft such as the Airbus A380 have over a thousand such brackets. Also, due to the high loading of the brackets and thus the thickness of the material used to make the brackets to ensure they can withstand such loads, each bracket is of a significant enough weight that the total weight of all of the hundreds of brackets utilised in the aircraft structure becomes substantial. Weight in aircraft design is very significant, as the heavier an aircraft is, the more fuel it requires to fly from A to B and as the aircraft is designed with a maximum all up weight the potential payload of the aircraft is reduced as the weight of the fuel and the structure increases. Any savings in aircraft weight or manufacturing costs offer significant advantages to the aircraft manufacturer and operators.

It is an object of this invention to design and manufacture a bracket that will alleviate the issues described above.

According to a first aspect of the present invention there is provided a method of forming a bracket including the steps of:

(i) cutting out a blank, having at least one fold line defining first and second regions of the blank, from a sheet of composite material,

and then, using a forming tool

(ii) undertaking a bending operation to bend the blank about the at least one fold line to create a predetermined angle between said first and second regions to form the required three-dimensional shape,

(iii) curing the bracket.

The bracket may be cured at the same time as the bending operation is undertaken or for part of this time or once the bending operation is completed.

The forming tool may be configured so that it can be set to create different values of said predetermined angle allowing different three-dimensional shaped brackets to be formed from the same original blank. Further bending operations may be undertaken about further fold lines to create more complex three-dimensional shapes.

This invention provides a simpler and quicker and thus more cost effective method of producing a bracket than forging and than machining to finish a metal bracket. Forging requires a different mould/tool for each bracket that has a different three-dimensional shape. Any bracket that can be formed, using the method of the present invention from the same blank, can be formed to its finished three-dimensional shape using the same tool and resetting the angle to which the blank is bent. Indeed, the tool can be manufactured so that different patterns of blank can be bent to the required three-dimensional shape, by including in the tool designing movable locating points for holding the blank during forming.

In some patterns of blank all the surfaces that are in contact with components to be attached are on the same surface of the blank. This allows the tool to be "one-sided", as only the surface in contact with the component need be made to a smooth finish that, once again, makes the process less expensive.

The tool can be placed into, or even incorporated in, an autoclave or other pressure and/or temperature device, so that curing of the bracket can take place during or directly after the forming process.

After curing the bracket is complete and there is no need for further machining or other finishing process, unlike with the forged bracket.

According to a second aspect of the present invention there is provided a blank cut from a sheet of composite material for forming a bracket having at least one fold line defining first and second regions of the blank so that when the blank is bent about the at least one fold line creating a predetermined angle

between first and second regions a three-dimensional bracket is formed. The blank may be substantially Z-shaped in profile.

The composite material the blanks are cut from may comprise fibres such as carbon fibre or glass fibre and the matrix surrounding the material could be, for example, thermoplastic or thermosetting resin material.

An initial stage of manufacture may be to build up material sheets by laying up several thin layers, or plies, on top of one another and the sheets so produced may be tailored to suit different structural requirements by using different numbers of plies and by orienting the fibres in different plies in different directions. If more strength is required additional fibres can also be introduced at key areas of the blank, for example, additional 90° fibres at and around the fold line. The matrix may be introduced into the fibre plies before laying up, in which case the material is known as 'pre-peg'. In an alternative method, the matrix may be introduced into the fibre plies after laying up; in this case the fibre plies may initially be stitched together or a binding agent may be used to bind them together temporarily.

One method by which a bracket having additional fibres at and around the fold line could be made is to lay up a sheet from layers having the majority of the fibres in each layer orientated in substantially the same direction and a majority of the layers are aligned in a main direction. A blank cut from such a made sheet is placed on a tool to form the bend about the fold line and the blank is constrained against movement in a direction substantially perpendicular to the plane of the said main direction layers, wherein force is applied to the blank in the plane thereof in a direction substantially perpendicular to the said main direction of said fibres, thereby to urge the blank to bend as required whilst substantially maintaining the continuity of the said fibre.

Depending on the viscosity of the resin of the composite article, heat may need to be applied thereto in order to ensure that the layers, or laminates, are able to slide with respect to each other.

The profile of the blanks may be cut from the sheet material by hand or by using an automatically controlled cutting technique, such as water-jet or laser

cutters. Whichever method is used, it is relatively simple after the profiles to suit different designs of blank. The blanks thus cut out may be stored until required for the next stage of manufacture.

It is feasible to store the blanks as they are purely shapes cut from sheet material and thus, unlike rough forgings that would require extensive storage space, economical to store. This allows large production runs to be undertaken, achieving economies of scale. If thermoplastic materials are used an individual blank can be formed into a finished bracket in under 10 minutes, a much shorter time than forging and then finishing a bracket, allowing large production runs to be undertaken in relatively short period of time.

The blanks can then be formed by a bending operation into the required three-dimensional shape.

The bending operation may be a manual or automated process.

If the material blanks are made from thermoplastic resin, then the blanks may have to be heated prior to, and during, forming and pressure may be applied to the material during the forming process; on subsequent cooling they will retain the new form they have been given. If the blanks are made from pre-peg, then the blanks will have to be cured in their new shape by the application of heat and pressure, which may be done whilst on the forming tool in an autoclave or by other suitable means. If the blanks are not pre-impregnated with a matrix material, then the tool used for forming may also be used to introduce the matrix material to the blanks before curing takes place.

According to a third aspect of the present invention a bracket may be formed from a blank produced as described above and then undertaking a bending operation to bend the blank about the at least one fold line to create a predetermined angle between said first and second regions to form the required three-dimensional shape.

According to a fourth aspect of the present invention there is provided a bracket formed from a single cut-out shape from a sheet of composite material cut into a predetermined shape. The cut-out shape may have at least one fold

line defining first and second regions of the bracket about which the material has been bent to form a three-dimensional bracket shape.

Brackets made in accordance with the present invention have been found to be 15% lighter than the equivalent bracket in aluminium alloy. A significant weight saving.

The brackets may then have fastener holes drilled as required. They may then be assembled into structures in a similar way to the metallic brackets of the prior art. They may be used together with surrounding structural components made from any of the usual materials such as metal alloys or from composite material.

According to a fifth aspect of the present invention there is provided a tool for forming a bracket as described above comprising two surfaces on which the blank is placed connected by a hinge, the fold line of the blank being aligned with the hinge and the hinge being set to allow the blank to be bent about the fold line to the predetermined angle to form the three-dimensional bracket required.

Tooling for forming the brackets can be made much more simply than forging moulds, as there is no requirement for the tool to match all the surfaces of the finished bracket. All that is required is that the bracket is securely positioned so that the fold line is correctly positioned on the hinge and the amount of bending is carefully controlled.

Also an added advantage is that the tool can be used for many different finished brackets, once again cutting down on tooling costs.

According to a sixth aspect of the present invention there is provided a component made from composite material having an integral bracket, said bracket formed from a shaped sheet of composite material having at least one fold line defining first and second regions of the bracket about which the material has been bent to form a three-dimensional bracket shape.

If the bracket is formed from part of one of the components to be joined, less attachment points and fasteners are required, making the joint stronger and lighter.

According to a seventh aspect of the present invention there is provided an aircraft wing rib and stringer arrangement including a series of brackets wherein each bracket in the series is formed from composite sheet material cut to the same general profile. Each of the brackets may havine at least one fold line, defining first and second regions of the bracket, about which the bracket is bent to a predetermined angle defined by the position of the rib and stringer.

Brackets are especially suitable for joining aircraft rib and stringers, as the basic design of each joint in a particular wing is similar, but the angle between the components changes and thus the angle of the bracket as you move down the wing from the root to the tip.

The brackets as described in any aspect of the invention above may be used in construction of aircraft and are especially suitable for use in aircraft wing construction.

An embodiment of the present invention will now be described with reference to the accompanying drawings in which:

Figure 1a shows an example of an angle bracket;

Figure 1b shows the angle bracket of Figure 1a inverted and viewed from the rear;

Figure 2a shows an example of a box bracket;

Figure 2b shows the box bracket of Figure 2a viewed from the rear;

Figure 3a shows an example of a butterfly bracket;

Figure 3b shows the butterfly bracket of Figure 3a viewed from the rear;

Figure 4 shows a part of an aircraft wing construction having wing rib to wing stringer joints;

Figure 5 shows a blank in accordance with the present invention cut from composite material;

Figure 6 shows the blank of Figure 5 having been formed to the required three-dimensional shaped bracket;

Figure 7 shows the bracket of Figure 6 on a forming tool used to bend the blank of Figure 6 to the required three-dimensional shape;

Figure 8 shows a finished bracket according to the present invention;

Referring firstly to Figures 1 to 3, examples of brackets used in aircraft manufacture as well as other constructions are shown. Figures 1a and 1b show an angle bracket 10 used to joint two components (not shown), the components being attached to surfaces 12 and 14 with fasteners such as bolts and nuts 16, through holes 18a, 18b drilled in the bracket 10.

Figures 2a and 2b show a box bracket 20 used to join at least two components, the components being attached at surfaces 22, 24, 26, 28.

Figures 3a and 3b show a butterfly bracket 30 used to join at least two components, the components being attached at surfaces 32 and 34.

Figure 4 shows how complex structures can be joined using brackets as described above.

Part of a wing box 40 is constructed using butterfly brackets, 42a, 42b, 42c, to join stringers 44a, 44b, 44c to rib 46.

Figure 5 shows a blank 50 in accordance with the present invention cut from a sheet of composite material with a resin matrix. A fold line 52 defining regions 54 and 56 is marked on the upper surface of the blank to act as a guide during the subsequent bending operation. The blank 50 is substantially 'Z'-shaped. This shape allows a bracket suitable for use where a butterfly bracket 30 according to the prior art would previously have been used to be formed in a one-stage forming process.

Figure 6 shows the blank 50 having been bent about the fold line 52. Region 54 is no longer in the same plane as region 56. The angle between the two regions 54, 56 can be controlled to create the required three-dimensional shaped bracket.

As the blank is bent about fold line 52 curve 58 is formed. By setting the size of the hinge (not shown) or other bending device used, the angle of curvature of curve 52 can be controlled. If required additional 90° fibres can be included in the lay up of the composite material from which the blank 50 is cut at the location of the curve to provide additional strength characteristics.

Figure 7 shows the blank 50 of Figure 6 on the tooling 70 used to bend the blank 50 to the required bracket shape. The tooling 70 comprises two forming plates 74, 76 attached via a hinge or other hinge-like mechanism that will allow the plates 74, 76 to rotate with respect to each other. In this example plate 76 is held fixed and plate 76 is allowed to rotate about the hinge that has previously been aligned with fold line 52 and the blank 50 secured in position.

Figure 8 shows a finished bracket 80 that has been formed as described above and with fastener holes 82a, 82b, 82c, 82d drilled ready for use.